THE NUTRITIONAL CARE OF CASES OF EXTENSIVE BURNS*

WITH SPECIAL REFERENCE TO THE ORAL USE OF AMINO-ACIDS (AMIGEN) IN THREE CASES

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NEW YORK, N. Y.

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THE NUTRITIONAL STATUS of extensive burns may be discussed under three headings: Loss of nitrogen; the change in plasma protein levels; and the nitrogen intake, which may include delayed blood and plasma transfusions.

Loss of Nitrogen: Lucido,[1] in 1940, published his metabolic studies on a case of burn estimated as involving 40 per cent of body area. He reported that the patient had a high urinary excretion of nitrogen for the first 25 days following the burn. An analysis of his published chart reveals that the output of urinary nitrogen was not consistent. The variations which occurred from day to day ranged between a maximum of 28 and a minimum of 10 Gm. per day. Browne[2] studied the nitrogen output in three cases of burns, one complicated by a fracture. On a regular diet all showed an elevated urinary output to as high as 28 Gm. per day, gradually dwindling down to normal on the 40th day to the 52nd. Taylor, Levenson, Davidson, Adams and McDonald,[3] in 1943, reported an excretion of as much as 45 Gm. of nitrogen in 24 hours, and called attention to the nitrogen deficit which would inevitably result from the cumulative loss. Cope, Nathanson, Rourke and Wilson[4] found that the level of nitrogen excretion in most cases of burns was comparable to that which occurs in normal persons, the highest amount which they reported being 22 Gm. (calculated from their published charts). The negative nitrogen balance was attributed by these workers to low intake; and the fact that the amount of nitrogen excreted was small appeared to be referable to absence of infections. Taylor, Levenson, Davidson, Browder and Lund,[5] in a later communication, reported one case of extensive burns, involving 45 per cent of the body surface in third-degree, and 10 per cent in second-degree burns, who excreted as much as 34 Gm. of nitrogen in the

* Initiated under a grant from Williams-Waterman Fund of Research Corporation and being continued under a contract recommended by the Committee on Medical Research between the Office of Scientific Research and Development and New York University.

Read in abstract form before the Committee on Convalescence and Rehabilitation of the Medical Research Council, November 16, 1943.

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urine on some days. His published chart, when analyzed, showed an average excretion of 27.5 Gm. daily the first week, gradually declining but not reaching normal until the seventh week. None of these authors mentioned the possibility that the large early loss might be partly accounted for by hemoglobinuria, which was reported by Lucido and Taylor, and associates, as being present in their cases.

The Plasma Protein Level: The serum protein level in Lucido's case was 4.9 Gm. per cent on the third day following the burn, and gradually rose to between 5–6 Gm. per cent during the subsequent period of observation. Cope, *et. al.*, reported a total plasma protein level of 5.5 Gm. per cent for a burn involving 11 per cent of body surface on the 39th day. In the case reported by Taylor, *et. al.*, the level of total plasma protein fell to 3.1 Gm. per cent. Only 1.6 Gm. per cent of albumin was present, accompanied by massive edema, until strenuous efforts were made to increase the protein intake, when the level rose to only 6 Gm. per cent. These protein figures observed in the latter stages of burns clearly demonstrate the presence of hypoproteinemia.

In a still more recent communication, Taylor's group[6] showed that of 81 patients with burns who were studied, 40 had hypoproteinemia. This condition, moreover, seemed to have a definite correlation with the severity of the burns. In 12 having burns affecting between 10 and 50 per cent of the body surface, eight, or 75 per cent, showed progressive hypoproteinemia. In 51 cases with burns involving less than 10 per cent, however, eight, or 15 per cent, showed a reduction in the amount of plasma proteins.

The Nitrogen Intake: The maximum nitrogen intake of Lucido's case was 120 Gm. of protein (19 Gm. N) toward the end of his study period. Cope, *et. al.*, cases had intakes of from 10 to 32.5 Gm. of nitrogen per day, the latter figures being made up mostly of large transfusions. In Taylor, *et. al.*, cases, the intake fluctuated between 35 Gm. of protein to 100 Gm. a day, until the 12th week, when the low plasma protein mentioned above was found and "the clinical condition was desperate." Then the intake was increased by administering additional protein in the form of 75 Gm. of albumin units and several units of desiccated plasma intravenously and *per os* through a stomach tube. On some of the days of special treatments, the protein intake was as high as 500 Gm.

In regard to the problem of protein intake, Taylor's group,[6] in their most recent paper, state that:

"In all burned patients admitted to this hospital, an attempt was made to meet the demand for protein by increasing the protein intake to from 100 to 125 Gm. a day. Even at this level, there was a marked negative nitrogen balance in nine patients with severe burns. Most of the patients with minor burns of less than 10 per cent of the body surface involved responded to the intake of 125 Gm. of protein a day with a return of their plasma protein to normal; but in those patients with a continued marked loss of nitrogen into the urine, this did not occur. Indeed, in some of the severely burned patients, it has been calculated that on the basis of the loss of nitrogen into the urine alone, 300

Gm. of protein a day would have been required to maintain nitrogen equilibrium. In addition to this loss, some patients continued to lose large amounts of nitrogen material from the burned surface for long periods of time. This insensible loss could not be calculated. The restoration of protein under these combined circumstances was a difficult problem, since the amounts required were considerably greater than those the patients could ingest."

The present work deals with the nutritional care of three cases of thermal third-degree burns of, respectively, 10, 30 and 50 per cent of body surface. The administration of a high caloric and high nitrogen intake as amino-acids (amigen) *per os* sufficed to maintain nutrition. The nitrogen balance was followed, for a varying period of time, throughout convalescence and the plasma proteins and body weight were determined periodically.

CASE REPORTS

Case 1.—J. C., male, age 53 (Table I), was admitted, February 7, 1943, with second- and third-degree burns of both hands and third-degree burns of face and head. On entrance, his burns were sprayed with sulfathiazole solution in another hospital, but on the next day he was transferred to the Bellevue Hospital where débridement was performed and vaselined gauze applied. On February 12, 1943, when he came under the care of the Nutrition Service, he had lost 4.5 Kg., his hematocrit was 48, and plasma protein level 4.7 Gm. per cent; cephalin flocculation test 3+++. He was given 500 cc. of plasma and immediately put on a diet consisting of 35 Gm. of nitrogen in the form of amigen, his caloric intake being 4500 daily. This intake was maintained with but slight variation throughout his stay in the hospital, a period which ended April 14. His nutritional state was excellent throughout his recovery. Thus, on February 23, ten days after he was placed on this diet, his plasma proteins had risen to 6.63 Gm. per cent, and his weight was 55.7 Kg., which was only 0.8 Kg. below his initial weight of 56.8 Kg. On April 14, with most of the burned areas healed, he weighed 62.5 Kg., or 5.7 Kg. above his initial weight.

TABLE I

J. C., male, 53 yrs., admitted 2/7/43: 2nd-3rd degree burns, both hands. 3rd degree face and head

Date	Caloric Intake	N. Intake	Nitrogen Output: Urinary N.	Nitrogen Output: Dressing	Nitrogen Output: Fecal N.	Nitrogen Output: Total N. Output	N. Balance	P.P. Gm. Per Cent	Hem.	Wt.	Remarks
		Gm.	Gm.	Gm.	Gm.	Gm.	Gm.	A/C		Kg.	
2/6	Burned when falling into a fire, 10 per cent body surface, sprayed with sulfathiazole sol.										
2/7	Débrided										
2/12–14	9,756	74	24.33		4.42	28.75	+45.75?	4.7	48	52.2	2/12: 500 cc. plasma. ceph. floc. +++
2/14–17	13,250	99	51.98		6.63	58.61	+73.39?	2/15 6.39	2/15 47	2/17 53.7	2/17: ceph. floc. neg.
2/17–20	14,610	106.2	47.61		6.63	54.24	+48.36?	2/17 5.44	33		
3/20–23	14,610	106.2	36.79		6.63	43.42	+62.78?	6.63	2/23 38	2/23 55.7	Hb. 13 Gm.
3/23	14,610	106.2								58.8	Areas healing, excess granulat. in some areas
4/14	14,610	106.2						7.2	45	62.5	Referred plastic surgery for an old injured finger

Case 2.—J. McN., male, age 42 (Table II), was admitted June 29, 1943, with second- and third-degree burns on the right side of the trunk to midthigh, involving 30 per cent of body surface. He was débrided and vaselined dressings were applied. His weight on June 30, when his metabolic studies began, was 55.45 Kg. For the first five days, he received 24 Gm. of nitrogen and a caloric intake of 2600 a day. His urinary output during this period was roughly 17.5 Gm. per day, making an apparent positive nitrogen balance of 6.5 Gm. On the basis of these figures, he could afford to lose 6.5 Gm. of nitrogen per day in his exudate without utilizing his body nitrogen. This amount of intake was apparently insufficient, for his body weight on July 5 had fallen to 53.7 Kg. From July 4 to 7, his nitrogen intake was raised to 25.6 Gm., and in the period between the 7th and the 10th to 31.5 Gm., but his weight had fallen to 50.9 Kg. by the 10th. From the 10th on, his intake was raised first to 33.6 Gm. and then to 42.2 Gm.; and this latter intake was maintained until his discharge on October 2. On this increasing intake, his weight first stayed stationary and then went up, regaining and then, finally, topping his entrance weight. His plasma proteins showed a corresponding rise. His nutritional state was excellent throughout the rest of the convalescence.

TABLE II

J. McN., male, age 42, 2nd and 3rd degree burns, rt. side of trunk to midthigh (30 per cent of body surface)

Date	Caloric Intake	N. Intake	Nitrogen Output: Urinary N.	Nitrogen Output: Dressing	Nitrogen Output: Fecal N.	Nitrogen Output: Total N. Output	N. Balance	P.P. Gm. Per Cent A/G	Hem.	Wt.	Remarks
		Gm.	Gm.	Gm.	Gm.	Gm.	Gm.	A/G		Kg.	
6/29–7/1	5,240	48	31.79		1.64	33.33	+14.67?	6/29 4.96	6/29 48	6/30 55.45	Vaselined gauze dressing
7/2–7/4	7,496	66	57.56		2.31	59.87	+ 6.13?	4.48 7/2	7/2 42		DTs
7/4–7/7	8,090	78	64.5		2.31	66.81	+11.19?			7/5 53.7	
7/7–7/10	9,770	94.5	55.35	15.46?	2.31	57.66	+36.84?			7/10 50.9	7/9: Burned areas healthy
7/10–7/13	10,520	100.7	70.03		2.31	72.34	+21.16?	7/12 5.89	7/12 45		
7/13–7/16	10,800	126.6	52.52		2.31	54.83	+65.67?				
7/16–7/18	7,200	84.4	37.57		1.54	39.11	+40.29?				7/15: 1.6 epithelized
7/16–7/20				14.22?				7/19 6.02	41	7/19 50.7 31.4	7/20: 40 per cent healed
7/22–7/17				14.92?				7/25 6.92	7/25 47	7/27 51.8	7/23: 50 per cent healed
8/3											80 per cent healed
8/2–8/ 7				4.44?							
8/27										55	
10/2										57.5	Healing complete

Attempts were made to collect the exudate from the burned surface. Since a great deal had seeped through the gauze dressings into the bedclothes, the nitrogen loss into the dressings is at best a minimum figure. It was 5.15 Gm. per day for the 8th to the 11th days.

Case 3.—M. W., colored, female, age 38 (Table III), suffered second- to third-degree burns on the trunk, right arm, buttocks, and left thigh on February 8, 1943. The burned area was estimated as involving 50 per cent of body surface, 90 per cent of the burns being third-degree. Her normal weight was 65.9 Kg. She was admitted in shock, was débrided, and tannic acid solution was applied. Between the date of her admission and April 16th, when she came into the Nutrition Service, she had 15 whole blood transfusions. She was also on the regular ward diet consisting of approximately 10 Gm. of nitrogen. On her admission into the Nutrition Service, her blood pressure was 90/50; and she was in very poor nutritional state, with a total plasma protein level of 4.31 Gm. per cent, hemoglobin 8 Gm., hematocrit 40. A 500-cc. transfusion of plasma was given. During the first three days of controlled study, she excreted 16.13 Gm. of nitrogen in her urine, averaging over 5 Gm. a day, a starvation level of excretion. She was then placed on 27.44 Gm. of nitrogen a day for three days, then increased to 36 Gm. daily for four days. Her urinary nitrogen during these two periods rose to 9 Gm. a day. Her apparent positive nitrogen balance rose from 3.5 to 24 Gm. a day. Her plasma proteins were 5.25 Gm. per cent; her hematocrit stayed at 39, and she showed no perceptible improvement, her weight on April 13th being 50.7 Kg.

TABLE III

M. W., female, age 38, 2nd-3rd degree burns, trunk, rt. arm, buttocks, left thigh, preburn wt. 65.9 Kg.

			Nitrogen Output								
Date	Caloric Intake	N. Intake Gm.	Urinary N. Gm.	Dressing Gm.	Fecal N. Gm.	Total N. Output Gm.	N. Balance Gm.	P. P. Gm. Per Cent A/G	Hem.	Wt. Kg.	Remarks
2/8–2/9	Burned on 2/8, 30 per cent surface area, admission B/P 40/15, débridement and tannic acid spray										
2/9–4/6	15 blood transfusions 500 cc. each, regular ward diet.										
4/6–4/9	6,300?	30?	16.13				13.87?	5.31	40	50.9	Hb. 8 Gm.
4/9–4/12	9,465	82.32	23.96				59.36?				
4/13–4/17	15,135	143.85	37.73				106.12?	4/15 5.25	39	4/13 50.7	No perceptible improvement
4/18											500 cc. blood—25 per cent burned area grafted
4/19										51.3	Condition improving
4/21–4/23	9,500	99.00	18.94				80.06?	4/23 6.19	35		500 cc. blood—80 per cent grafts taking
4/28–4/30	9,500	99.00	14.18				83.82?				
5/2											Improving slightly
5/8–5/11	19,900	198	52.62	19.34?			145.38?				
5/17	6,550	66								53.57	Improving rapidly
6/15	6,550	66						6.8	42	59	Hb. 11 Gm. L. thigh and buttocks graft
6/30–7/22	6,550	66									Rt. shoulder and arm grafted
7/30	6,550	66								61.8	All grafts taking
8/10	6,550	66									
8/25	Amigen discontinued, put on high protein diet										
9/15										63.6	Most areas healed

She was given a blood transfusion in order to prepare her for the application of skin grafts to one-quarter of her burned area. Soon after the skin grafts were applied, her blood pressure fell to 80/40, a shock-like state which persisted until a blood transfusion was given. The significance of this will be discussed later in the paper. Her intake was increased to 35.77 Gm. daily and this continued for six days; *i.e.*, until April 19, when she began to improve and to show some gain in weight which was then 51.3 Kg. Her appetite improved and her intake was increased to 49.5 Gm. daily, at first, and then to 66 Gm., on which she improved rapidly, so that on May 17 her weight was 53.57 Kg. It may be mentioned that the exudate from the burned areas collected in the dressings in the four-day period between May 7 and 11 was found to contain 19.34 Gm. of nitrogen, or roughly 4.84 Gm. daily. These, again, are minimum figures, since some of the exudate was lost by seepage through the dressings. This minimal figure does not represent the amount lost in the areas not covered by the grafts, roughly, now 40 per cent of the body surface. On June 15, her plasma proteins were

6.8 Gm. per cent, and her weight 59 Kg., and hemoglobin 11 Gm. per cent. From then on, she ceased to be a nutritional problem.

Discussion: It appears that cases of burns of any appreciable extent of body surface tend to develop a state of malnutrition. The necessity for transfusions after the acute period is passed may be taken as rough index of the nutritional state of burn patients. Of the 38 cases reported by Cope's group, only five with burns over 20 per cent reached convalescence. On four of these the extent of the burned area ranged from 24.5 to 29 per cent of the body surface. The latter group required delayed transfusions of one to five units. The only instance on whom the blood protein level was reported was on a case in which 11 per cent of body area was involved. The plasma proteins on the 39th day were 5.5 Gm. per cent. In our Case 2, J. McN., in whom the burned area comprised 30 per cent of the body surface, as much as 4.5 Kg. was lost during the ten days following the accident. A plasma protein level of 4.48 Gm. per cent was noted on the third day and nutrition could not be maintained on 25.6 Gm. of nitrogen daily, an amount exceeding that of a classical high protein diet. Of the three cases available for study in whom over 50 per cent of the body surface was involved, Cope's case needed 25 transfusions during convalescence, and, inferentially, must have been in a precarious nutritional state. Taylor's case had lost 55 lbs. by the end of the third week, although already showing some improvement. The poor nutritional state of our Case 3, M. W., needs no comment. And in their latest paper, Taylor's group[6] reported that a loss of as much as 30 per cent of the body weight had occurred in some of the patients studied as a result of failure to maintain adequate nutrition.

When it is considered how many sources of nitrogen loss are present in burns, this poor nutritional status is understandable. There are at least four, perhaps five, avenues for this loss: (1) The intratissue loss into the burned areas, which may or may not be recoverable by the body; (2) the loss occurring in the exudate; (3) the loss as a result of hemoglobinuria; (4) the loss as a result of poor caloric and nitrogen intake consequent to anorexia; and (5) the possible loss due to a "antianabolic period" as a result of altered hormonal physiology.[7]

In this connection, Clowes, Lund and Levenson[7] reporting on 150 cases of burns, 109 of whom were victims of the Cocoanut Grove disaster, stated: "All patients with 10 per cent of surface area or more involved in third-degree burns became serious nutritional problems because of the loss of nitrogen in the urine and from the surface, and because of the increased nutritional requirements resulting from infection with fever."

Two preliminary attempts on our part to determine the protein loss in body exudates more quantitatively than in Cases 2 and 3 may be mentioned to illustrate how large this loss may become. Slabs of fine-pored cellulose sponges were used to collect the exudates. One case exuded as much as 0.42 mg. of nitrogen per square centimeter in 24 hours, while another case of denuded surface due to avulsion, exuded as much as 2.26 mg. nitrogen per square centimeter. If half of the body surface of a man weighing 70 Kg., and 170 cm. in height, were to be involved in a burn, the 9,050 sq. cm. so involved would lose, according to one rate, 3.8 Gm. and according to the other rate, 19.9 Gm. of nitrogen in 24 hours. Three point eight grams of nitrogen would be 23.75 Gm. of protein, or the equivalent of 4,000 cc. of plasma; or of 114 Gm. of meat; and 19.9 Gm. of nitrogen would be equivalent to 124 Gm. of protein, over 2000 cc. of plasma, and 600 Gm. of meat.

The problem of keeping Case 1 in good nutrition was relatively simple. Cases 2 and 3 were somewhat more difficult. As it happened, the amount of nitrogen in the form of amino-acids fed to these three cases of increasing severity seemed to present a trend quantitatively in keeping with the extent of burns. Case 1 was kept in good nutritional state by 35 Gm. of nitrogen in the form of amino-acids. How much less might be required we are not in a position to know. Case 2, however, with the 30 per cent area burns could not be kept in good nutrition by 25.6 Gm. of nitrogen; while 33.6 Gm. maintained him, and with 42.2 Gm. he registered a rapid gain. Case 3 was not maintained by 36 Gm., but was maintained by 49.5 Gm., and registered a rapid gain with 66 Gm. It is quite possible that, as in the case of 35 Gm. for Case 1, so might 42.2 Gm. and 66 Gm. be supra-optimal for Cases 2 and 3. Table IV shows these amounts and their conversion values into meat and plasma. The amount of transfusion used in these cases was minimal, being *nil* in Cases 1 and 2, and only three transfusions were administered during the entire period of nutritional study in Case 3. It will be seen from the conversion table (Table IV) that to maintain a patient in good nutritional state under circumstances similar to our patients in Cases 2 and 3 with either meat feeding or plasma transfusion is almost an impossible task physically and economically.

TABLE IV

Patient	Original Body Wt. Kg.	Area Burned Percent	Total Daily N. Intake Gm.	N. in Gm. Wt. Kg.	Total Equivalents: Proteins* Gm.	Meat* Gm.	Plasma* Cc.	Remarks
J. C.........	56.8	10	35	0.62	218.75	1093	3644	Sufficient
J. McN......	55.45	30	24	0.43	130	750	2500	Insufficient
			25.6	0.46	160	800	2650	Insufficient
			33.6	0.61	210	1050	3500	Maintenance
			42.2	0.76	263.75	1318.75	4400	Rapid gain
M. W........	65.9	50	27.44	0.42	171.5	857.5	4570	Insufficient
			36	0.55	225	1125	3750	Maintenance
			49.5	0.75	309.4	1485	5160	Slight gain
			66	1.00	412.5	2062.5	6875	Rapid gain

* Conversion table of nitrogen intake into proteins, meat and plasma. The assumption is made that meat contains 20 per cent protein, and the plasma, as now prepared, contains 6 Gm. per cent of proteins.

Thus, to feed a patient meat equivalent to the nitrogen intake of Case 3, M. W., would require the daily ingestion of about two kilograms of meat, an impossible task. To give this amount of proteins in the form of plasma transfusions would require 23 units of plasma daily. The amigen corresponding to this nitrogen intake costs in the neighborhood of three dollars. The corresponding amount of meat would cost at least four times as much, while the cost of a corresponding amount of plasma would be prohibitive.

For this reason preparations, such as amigen, used in the three reported cases appear to be the solution to the problem of nutritional care in severe cases of protein drain. The rather logical way in which the dosages of amino-acids corresponded to the extent of the burned areas raises the hope that it might be possible to work out a practical formula of amino-acid feeding for burns of different extent.

The development of shock following immediately upon the first skin grafting in Case 3, M. W., is a phenomenon which may have an important bearing on the safety of this procedure in cases of extensive burns. Her plasma protein level at this time was 5 Gm. per cent. Theoretically, it is to be expected that in patients undergoing severe protein loss with protein synthesis barely keeping up with the loss, the opening up of new areas of the skin surface, with resulting increase in exudation and bleeding, would readily lead to the development of shock. If this explanation is correct, then patients in this condition should have no skin grafting attempted unless the protein nutrition has been improved and measures for the therapy of shock are at hand. The increase of the exudative surface would be at the highest point during the first two days before the graft has taken. Even after that, if all the graft has taken, the contraction of the graft would prevent this graft in the early stages from compensating for the exudation from the new donor areas.

SUMMARY AND CONCLUSIONS

1. The nutritional status of three cases of second- and third-degree burns involving, respectively, 10, 30 and 50 per cent of body area, given high caloric and high nitrogen feedings in the form of dextrimaltose and amigen were studied.

2. All three patients were maintained in excellent nutritional state.

3. There seemed to be a mathematical relationship between the extent of surface burned and the amount of nitrogen required to maintain nutrition.

4. Transfusions were reduced to a minimum.

5. Preparations such as amigen seem to be better tolerated and utilized than natural protein food and appear to be the solution to the problem of nutritional care of severe cases of protein drain.

6. The increased danger to patients with severe protein deprivation of the development of shock as a result of additional protein loss consequent upon opening up of new exuding areas in skin grafting has been discussed.

Grateful acknowledgment is made of the help of Dr. Stanley Sarnoff in suggesting the use of cellulose sponges for the collection of exudates and of that of David Gould in performing the palar planimetry.

REFERENCES

[1] Lucido, J.: Metabolic and Blood Chemical Changes in Severe Burn. ANNALS OF SURGERY, 111, 640, 1940.

[2] Browne, J. S. L., and Josiah Macey, Jr.: Foundation Report on Bone and Wound Healing. Second Meeting, December 11–12, p. 50, 1942.

[3] Taylor, F. H. L., Levenson, S. M., Davidson, C. S., Adams, M. A., and MacDonald, H.: Abnormal Nitrogen Metabolism in Burns. Science, **97**, 423, 1943.

[4] Cope, O., Nethamson, I. I., Rourke, G. M., and Wilson, H.: Metabolic Observations. (Management of the Cocoanut Grove Burns at the Massachusetts General Hospital). ANNALS OF SURGERY, **117**, 937, 1943.

[5] Taylor, F. H. L., Levenson, S. M., Davidson, C. S., Browder, H. C. and Lund, C. C.: Problems of Protein Nutrition in Burned Patients. ANNALS OF SURGERY, **118**, 15, 1943.

[6] Taylor, F. K. L., Levenson, S. M., Davidson, C. S., and Adams, M. A.: Abnormal Nitrogen Metabolism in Patients with Thermal Burns. New England Jour. Med., **229**, 855, 1943.

[7] Albright, F., and Browne, J. S. L.: Josiah Macey, Jr. Foundation. Report of Conference on Bone and Wound Healing. Second Meeting. December 11–12, p. 55, 1942.

[8] Clowes, G. H. A., Jr., Lund, C. C., and Levenson, S. M.: A Surface Treatment of Burns. ANNALS OF SURGERY, **118**, 761, 1943.